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ORIGINAL ARTICLE

Infrastructure investment in Portugal and the traded/non-traded industry mix†

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ABSTRACT

Using a newly-developed data set for Portugal, we analyze the industry-level effects of infrastructure investment. Focusing on the divide between traded and non-traded industries, we find that infrastructure investments have a non-traded bias, as these shift the industry mix towards private and public services. We also find that the industries that benefit the most in relative terms are all non-traded: construction, trade, and real estate, among the private services, and education and health, among the public services. Similarly, emerging trading sectors, such as hospitality and professional services, stand to gain. The positive impacts on traded industries are too small to make a difference. These results highlight that infrastructure-based strategies are not neutral in terms of the industry mix. Moreover, with most of the benefits accruing to non-traded industries, such a development model that is heavily based on domestic demand may be unsustainable in light of Portugal's current foreign account position.

Keywords*: infrastructure investment; economic performance; industry mix; traded and non-traded sectors; VAR; Portugal*

1. Introduction

This study estimates industry-specific effects of infrastructure investment in Portugal using a newly developed data set (see Pereira and Pereira (2016)). We consider five main types of infrastructure assets and twenty-two industries that cover the whole spectrum of economic activity. In this context, we address two research questions. First, which industries benefit the most in absolute terms from the different types of infrastructure investments. Second, which industries stand to gain the most, relative to their size. Together, we identify, in general, how infrastructure investments have affected the composition of economic activity, i.e., the industry mix. More specifically, we are interested in highlighting the differences across the divide between traded and non-traded industries.

The economic effects of infrastructure investments were first analyzed by Aschauer (1989a, 1989b). The empirical literature that has since developed is both extensive and focusing on several issues, not

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only at the aggregate but also at the regional levels, both for the U.S. and for other countries (see, for example, Munnell (1992), Gramlich (1994), Kamps (2005), Romp and de Haan (2007), Pereira and Andraz (2013), and Bom and Ligthart (2014) for literature surveys). Nevertheless, studies of these effects at the industry level are much less common.

Although some studies focus on specific industries, their focus is a regional one (see, for example, Evans and Karras (1994), Moomaw and Williams (1991), Gao (2004), Cantos *et al*. (2005), and Deliktas *et al*. (2009)). The industry-specific dimension is more relevant in studies that focus on the U.S. case and some of its industries (see, for example, Fernald (1993), Gokirmak (1995), Nadiri and Mamuneas (1994), Greenstein and Spiller (1995), Holleyman (1996), Pinnoi (1992), and Pereira and Andraz (2003)). The international evidence at the industry level is also growing, although it is usually restricted to specific sets of industries (see, for example, Paul *et al*. (2004) for Canada; Zhang *et al*. (2010) and Mantian (2010) for China; and Seitz (1994) for Germany; Mamatzakis (2007a) for Greece; Mitra *et al*. (2002, 2012) for India; Annala *et al*. (2008) for Japan; Shah (1992) and Mamatzakis (2007b) for Mexico; Pereira and Andraz (2007) for Portugal; Pereira and Roca-Sagales (2001) for Spain; Berndt and Hansson (1992) for Sweden; and, finally, Lynde and Richmond (1993) for the U.K.).

One issue that is almost inexistent in this empirical literature on the impact of infrastructure investments at the industry level is the relationship between aggregate and industry-specific effects, specifically, how the aggregate effects can be decomposed at the industry level. This is a critical issue, since the relevance of the aggregate of the effects of infrastructure investments does not provide any useful information as to the industry incidence of such effects. Significant positive aggregate effects can be associated with balanced positive industry-level effects, or they can mask uneven gains across industries. Also, it is conceivable that small effects at the aggregate level could hide significant effects for specific industries. Ultimately, there is the question of how the development of an infrastructure network has affected the industry mix in the country.

The question of how infrastructure investments affect the industry mix is a critical one when we consider small open economies, such as Portugal, that rely on their export ability to sustain ongoing improvements in their standards of living. The effects of infrastructure investments, as these affect the industry mix along the divide between traded and non-traded goods and services, are thus an issue of the utmost importance. Infrastructure investments that affect mostly industries producing traded goods will help with this export-oriented development strategy, while those that are biased in favor of non-traded goods and services will create added pressure on the external accounts, thereby questioning the long-term feasibility of the development model. The aggregate effects of infrastructure investments may therefore hide divergent industry-specific patterns and thereby lead the economy into markedly different directions.

In this article, we answer the research questions using a multivariate dynamic time series approach, based on vector autoregressive (VAR) models that feature industry-specific output, employment, and private investment, in addition to the different types of infrastructure investments. This approach was developed in Pereira and Flores de Frutos (1999) and Pereira (2000, 2001), and was subsequently applied to the U.S. in Pereira and Andraz (2003, 2004) and then to Portugal in Pereira and Andraz (2005, 2007). Recent applications include Pereira and Pereira (2018a, 2018b). This econometric approach highlights the dynamic nature of the relationship between infrastructure

investments and economic performance, as well as the possible endogeneity of infrastructure investment decisions.

In terms of the scope of the analysis, the twenty-two different industries are grouped into the primary sector (which includes agriculture and mining) and the manufacturing sector (featuring food, textiles, paper, chemical, metals, machinery, and other equipment), which are traded goods industries, as well as the private service sector (which includes electricity, water, construction, trade, transportation, hospitality, finance, and real estate) and the public service sector (comprised of public administration, health, and education), which are mostly non-traded goods industries. Regarding the infrastructure investments, we consider five main groups of assets: road transportation infrastructures (including national roads, municipal roads, and highways), other transportation infrastructures (including railroads, ports, and airports), social infrastructures (including education and health infrastructures), public utilities (including water and wastewater, electricity, and gas and petroleum refineries), and telecommunications. For each industry, we estimate five different industry-specific models, one for each infrastructure type. Accordingly, this approach allows us to identify the long-term aggregate effects for each industry for each type of infrastructure investment.

The rest of this article proceeds as follows. Section 2 presents the economic and infrastructure investment data. Section 3 discusses preliminary econometric results, as well as the identification of exogenous shocks to infrastructure investment and the measurement of their effects. Section 4 presents the main evidence, as to the economic impact of infrastructure investments at the industry level, as well as their impact on the industry mix. Section 5 concludes with a summary of our results and a number of policy implications.

2. Data sources and description

2.1. The infrastructure investment data set

The data for infrastructure investment are from a new data set developed by Pereira and Pereira (2016) that covers 1978 through 2011. Infrastructure investment is measured in constant 2005 euros. It considers five main infrastructu re assets: road transportation, other transportation, social infrastructures, public utilities, and telecommunications. **Table 1** presents summary statistics.

Road transportation infrastructures include national roads, municipal roads, and highways, and account for 28.5% of total infrastructure for the sample period. Investment efforts and the extension of motorways in Portugal grew tremendously during the 1990s, with the last ten years marked by a substantial increase in highway investments made possible due to public-private partnerships. This corresponds in absolute terms to an increase from 0.74% of GDP in the 1980s to 1.52% in the last decade of the sample.

Other transportation infrastructures include railroads, airports, and ports, and account for 8.9.% of total infrastructure investment during the sample period. These investments reached their greatest levels, as a percent of total infrastructure investment, with the modernization of the railroad network and port expansion projects, while the last ten years has also witnessed substantial growth in investment in airports. In absolute terms, this reflects an increase from 0.22% of GDP in the 1980s to 0.46% in the last decade.

Table 1. Infrastructure investment by type of assets

	1980–2011	1980–89	1990–99	2000–09
		Percent of GDP		
Infrastructure Investment	**4.18**	**2.88**	**4.40**	**5.04**
Road Transportation	1.19	0.74	1.32	1.52
Other Transportation	0.38	0.22	0.47	0.46
Social Infrastructures	0.96	0.81	1.08	1.02
Utilities	1.08	0.70	0.83	1.43
Telecommunications	0.57	0.41	0.70	0.61
		Percentage of total infrastructure investment		
Infrastructure Investment	**100.00**	**100.00**	**100.00**	**100.00**
Road Transportation	28.49	25.99	30.35	30.23
Other Transportation	8.91	7.57	10.52	9.21
Social Infrastructures	23.76	28.41	24.52	20.13
Utilities	25.08	24.1	18.49	28.54
Telecommunications	13.77	13.94	16.12	11.89

Social infrastructures include health facilities and educational buildings. Social infrastructures account for 23.8% of infrastructure investment and show a slowly declining pattern over time in terms of their relative importance in total infrastructure investment. In absolute terms, however, these investments remained stable over the last two decades, representing just under 1% of GDP on average.

Public utilities include electric power generation, transmission, and distributions; water supply and treatment; and petroleum refining; as well as **telecommunications infrastructures**, which we consider separately. Together, these account for 38.9% of total infrastructure investment in the sample period, of which 25.1% refer to utilities and 13.8% to telecommunications. In terms of their relative importance, investment in utilities reached a relatively high relevance in terms of total infrastructure investment in the 1980s, driven by the expansion of the telephone network and substantial investments in major coal-powered electricity production units and in two refineries. More recently, the expansion of mobile communications networks, as well as investments in renewable energies, have contributed to the sustained growth in investment in utilities since 2000. In absolute terms, we witness a constant increase in the importance of investments in utilities from 0.7% of GDP in the 1980s to 1.43% in the last decade of the sample, while telecommunications have increased from 0.41% to 0.62% over the same time frame.

Overall, investment levels have grown substantially over the past thirty years, averaging 2.92% of GDP in the 1980s, 4.45% in the 1990s, and 5.17% over the last decade. The increase is particularly pronounced after 1986, the year in which Portugal joined the E.U., and in the 1990s when E.U. transfers within the context of the Structural and Cohesion Funds—Community Support Framework I (1989–1993) and Community Support Framework II (1994–1999)—stimulated a substantial increase in investment levels. The investment effort decelerated substantially in the last decade during Community Support Framework III (2000–2006) and QREN (2007–2013). These landmark dates for joining the European Union, as well as the start of the different community

support frameworks, are all considered as potential candidates for structural breaks in every single step of the empirical analysis that follows.

2.2. The industry data set

The economic data—output, employment, and private investment—are obtained from different annual issues of the National Accounts published by Statistics Portugal, available online at http://www.ine.pt. Output and private investment are measured in millions of constant 2005 euros, while employment is measured in thousands of employees.

We consider twenty-two industries, divided in four sectors: two primary industries (agriculture and mining), seven manufacturing industries (food, textiles, paper, chemical and pharmaceutical, non-metallic minerals, metallic, and machinery), ten private services industries (electricity, water, construction, trade, transportation, hospitality, telecommunications, finance, real estate, and professional services), and three public services industries (public administration, health, and education). In **Table 2**, we include details on the composition of each sector.

We use the share of exports in the output of each industry over the last decade to identify industries that produce internationally traded goods. We consider the two primary industries, seven manufacturing industries, and transportation as being traded goods industries. The remaining nine private service industries, as well as the three public service industries, are considered as non-traded. Here, however, we find it useful to categorize a few private service industries, such as water, hospitality, telecommunications, finance, and professional services, as emerging traded goods industries. In these industries, international trade plays a small but possibly increasing role.

Summary statistics on the industry mix are provided in **Table 3**. The output share of the primary and manufacturing sectors declined sharply over the sample period. The primary sector was 14.1% of output in the 1980s and declined to 3.4% in the last decade. Similarly, over the same period of time, the manufacturing sector declined from 20.5% to 15.1%. Transportation declined in the 1990s but somewhat rebounded over the last decade. The sectors producing traded goods overall declined from 39.8% of output in the 1980s to 23.1% in the last decade. Private services, net of transportation, increased slightly from 47.5% of output in the 1980s to 55.7% in the last decade, led by a large increase in the role of professional services. The largest increase was in public services, which rose from 12.8% in the 1980s to 21.2% in the last decade, a change due to large increases in each of its components.

Table 2. Industry classification

Primary Sector	
Agriculture (S1)	Agriculture, forestry, and fishing
Mining (S2)	Mining and quarrying
Secondary Sector - Manufacturing	
Food (S3)	Manufacture of food products, beverages, and tobacco products
Textiles (S4)	Manufacture of textiles, wearing apparel, and leather products
Paper (S5)	Manufacture of wood and paper products; printing
Chemical and pharmaceutical (S6)	Manufacture of chemicals and chemical products; manufacturing of basic pharmaceutical products and pharmaceutical preparations.
Non-metallic minerals (S7)	Manufacture of rubber and plastics products and other non-metallic mineral products
Basic metals (S8)	Manufacture of basic metals and fabricated metal products, except machinery and equipment
Machinery and equipment (S9)	Manufacture of computer, electronic, and optical products; manufacture of electrical equipment; manufacture of machinery and equipment; manufacture of transport equipment; manufacture of furniture; other manufacturing; repair and installation of machinery and equipment
Tertiary Sector - Private Services	
Electricity and gas (S10)	Electricity, gas, steam, and air-conditioning supply
Water (S11)	Water, sewerage, waste management, and remediation activities
Construction (S12)	Construction
Wholesale and retail trade (S13)	Wholesale and retail trade; repair of motor vehicles and motorcycles
Transportation and storage (S14)	Transportation and storage
Hospitality (S15)	Accommodation and food service activities
Telecommunications (S16)	Telecommunications
Finance (S17)	Financial and insurance activities
Real estate (S18)	Real estate activities
Professional services (S19)	Publishing, audiovisual and broadcasting activities; computer programming, consultancy and related activities; information service activities; legal and accounting activities; activities of head offices; management consultancy activities; architecture and engineering activities; technical testing and analysis; scientific research and development; advertising and market research; other professional, scientific and technical activities; veterinary activities; administrative and support service activities; arts, entertainment, and recreation; other services activities
Tertiary Sector - Public Services	
Public administration (S20)	Public administration and defense; compulsory social security
Education (S21)	Education
Health (S22)	Human health services; social work activities

Table 3. Industry composition

	Private Investment				Employment				Output			
	1978-2009	**1980-89**	**1990-99**	**2000-09**	**1978-2009**	**1980-89**	**1990-99**	**2000-09**	**1978-2009**	**1980-89**	**1990-99**	**2000-09**
Agriculture	**4.7**	**7.1**	**3.9**	**3.0**	**15.5**	**20.8**	**13.7**	**10.1**	**8.6**	**14.1**	**6.6**	**3.4**
Agriculture (S1)	3.8	5.1	3.5	2.6	14.5	19.1	13.0	9.7	6.7	10.2	5.6	2.9
Mining (S2)	1.0	2.0	0.4	0.4	1.0	1.7	0.7	0.3	1.9	3.9	1.0	0.5
Manufacturing	**13.1**	**15.7**	**12.3**	**10.7**	**21.8**	**25.0**	**21.7**	**18.0**	**18.1**	**20.5**	**18.5**	**15.1**
Food (S3)	1.4	1.3	1.3	1.6	2.7	3.1	2.6	2.4	2.1	2.0	2.2	2.1
Textiles (S4)	1.3	1.9	1.3	0.7	7.4	8.9	7.6	5.5	3.7	4.2	4.2	2.7
Paper (S5)	1.4	1.6	1.2	1.5	2.3	2.5	2.3	1.8	2.2	2.4	2.2	1.8
Chemical and pharmaceutical (S6)	2.0	2.2	1.5	1.3	0.8	1.1	0.7	0.5	1.7	2.3	1.5	1.2
Non-metallic minerals (S7)	2.0	2.6	1.7	1.6	2.0	2.2	2.0	1.8	2.7	3.4	2.6	2.0
Basic metals (S8)	1.1	1.2	1.0	1.0	2.3	2.6	2.2	2.1	2.5	3.5	2.1	1.8
Machinery and equipment (S9)	4.0	4.9	4.2	2.9	4.0	4.9	4.2	2.9	3.3	2.7	3.7	3.7
Private Services	**67.8**	**66.2**	**66.8**	**70.2**	**45.2**	**39.2**	**46.3**	**51.7**	**56.3**	**52.7**	**56.7**	**60.3**
Electricity and gas (S10)	4.9	8.0	1.7	3.9	4.3	4.6	4.2	3.9	2.1	1.8	2.4	2.2
Water (S11)	3.4	5.6	1.5	2.3	0.4	0.5	0.4	0.2	0.6	0.5	0.6	0.9
Construction (S12)	5.3	5.5	6.4	4.1	0.9	1.1	0.8	0.7	7.1	6.8	7.0	7.7
Wholesale and retail trade (S13)	5.6	4.7	6.2	6.3	10.7	10.5	10.1	11.4	15.4	16.8	15.1	14.1
Transportation and storage (S14)	5.8	5.1	4.4	7.9	13.9	12.0	14.5	15.8	4.6	5.2	4.3	4.6
Hospitality (S15)	1.9	1.6	2.1	2.2	3.5	3.8	3.3	3.4	3.7	2.7	3.9	4.7
Telecommunications (S16)	2.7	2.0	3.0	3.1	4.4	3.6	4.5	5.4	1.9	1.4	2.0	2.3
Finance (S17)	4.8	5.1	6.0	3.7	0.4	0.5	0.4	0.3	6.3	6.3	6.1	6.6
Real estate (S18)	26.6	24.8	28.2	27.0	2.3	2.5	2.5	2.1	7.5	6.0	7.4	8.0
Professional services (S19)	6.7	3.9	7.3	9.7	0.5	0.2	0.6	0.7	7.2	5.2	7.8	9.1
Public Services	**14.4**	**11.0**	**17.0**	**16.1**	**17.5**	**15.0**	**18.4**	**20.2**	**17.0**	**12.8**	**18.2**	**21.2**
Public administration (S20)	10.8	8.4	13.1	11.8	8.0	7.1	8.2	9.1	8.5	7.2	8.9	9.9
Education (S21)	1.7	1.5	2.0	1.8	5.7	4.7	6.2	6.6	5.3	3.6	6.0	6.8
Health (S22)	1.9	1.1	2.0	2.6	3.8	3.2	4.0	4.6	3.2	2.0	3.3	4.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

3. Preliminary data analysis[1]

3.1. Unit roots, cointegration, and VAR specifications

We start with unit root and cointegration analyses. Having determined that the stationarity seems to be a good approximation for all series, and in the absence of any evidence for cointegration, we follow the standard procedure in the literature and determine the specifications of the VAR models using growth rates of the original variables.

We estimate five VAR models for each of the twenty-two industries, one for each of the different infrastructure types, for a total of 110 models. Each VAR model includes industry-specific output, employment, and private investment, as well as the relevant infrastructure investment variables. We use BIC to determine the structural breaks and deterministic components to be included. Our test results suggest that a VAR specification of the first order with a constant and a trend, as well as structural breaks in 1989, 1994, and 2000, the years of the inception of the first three community support frameworks, is the preferred choice in the overwhelming majority of the cases.

3.2. Identifying exogenous innovations in infrastructure investment

The key issue in determining the impact of infrastructure investment is the identification of exogenous shocks representing innovations in infrastructure investments that are not contaminated by other contemporaneous innovations and avoid reverse causation. In dealing with this issue, we draw on the approach followed in dealing with the effects of monetary policy (see, for example, Christiano *et al*. (1996, 1999) and Rudebusch (1998)) and adopted by Pereira (2000) in the context of the analysis of the effects of infrastructure investment.

The identification of exogenous shocks to infrastructure investment would, in general, result from knowing what fraction of the government appropriations in each period is due to purely non-economic reasons. The econometric counterpart to this idea is to consider a policy function which relates the rate of growth of infrastructure investment to the relevant information set. The residuals from these policy functions reflect the unexpected component of the evolution of infrastructure investment and are, by definition, uncorrelated with innovations in other variables.

We assume that the relevant information set for the policy function includes past, but not current, values of the economic variables. In the context of the standard Cholesky decomposition, this is equivalent to assuming that innovations in investment lead innovations in economic variables, i.e., that while innovations in infrastructure investment affect the economic variables contemporaneously, the reverse is not true.

We have two reasons for this assumption. First, it seems reasonable to assume that the economy reacts within a year to innovations in infrastructure investments. Second, it also seems reasonable to assume that the public sector is unable to adjust infrastructure investment decisions to innovations in the economic variables within a year. This is due to the time lags involved in information gathering and public decision making. Furthermore, this assumption is reasonable also from a statistical perspective. Invariably, the policy functions point to the exogeneity of the innovations in infrastructure investment, i.e., the evolution of the different infrastructure investments does

[1] For the sake of brevity, we just sketch here the different steps in the preliminary data analysis. Full documentation is available from the authors upon request.

not seem to be affected by the lagged evolution of the remaining variables. This is to be expected because infrastructure investments were very much linked to E.U. support programs and therefore not responsive to the ongoing economic conditions. Moreover, we would not expect any single economic sector to have an impact on decision making for infrastructure investments at the national level.

3.3. Measuring the effects of innovations in infrastructure investment

To measure the effects of a one-percentage-point, one-time shock in the rates of growth of the different types of infrastructure investment on output, employment, and private investment for the different industries, we estimate the accumulated impulse response functions for each of the VAR models. Without exception, we observe that the accumulated impulse response functions converge within a relatively short time period. The error bands surrounding the point estimates for the accumulated impulse responses are computed via bootstrapping methods. We consider 90% intervals, although bands that correspond to a 68% posterior probability are the standard in the literature (Sims and Zha, 1999). From a practical perspective, when the 90% error bands for the accumulated impulse response functions include zero, we consider that the effects are not significantly different from zero.

To measure the effects of shocks in infrastructure investment, we calculate the long-term accumulated elasticities and the long-term accumulated marginal products of the different economic variables with respect to each type of infrastructure investment. These concepts depart from the conventional understandings because they are not based on *ceteris paribus* assumptions, but instead they include all the dynamic feedback effects among the different variables.

The long-term accumulated elasticities are to be interpreted as the total accumulated percentage-point long-term change in the other variables, per one-percentage point of accumulated long-term change in infrastructure investment. In turn, the long-term accumulated marginal products measure the dollar change in private investment and output, and the number of permanent jobs created, for each additional dollar of investment in infrastructures. The marginal products are obtained by multiplying the average ratio of each variable to infrastructure investment by the corresponding elasticity. We use the average ratio of the economic variable to the level of infrastructure investment over the last ten years of the sample. Using a recent time period allows the marginal products to reflect the relative scarcity of the different types of infrastructures at the margin of the sample period, while the choice of ten years prevents these ratios from being overly affected by business-cycle factors.

4. On the effects of infrastructure investment

4.1. The effects at the industry level: A first look

The aggregate results—the sum across all industries of the statistically significant effects—are reported in the last rows of **Table 4** to **Table 8**. When we consider the five main infrastructure assets, a clear pattern emerges. Investments in other transportation, in social infrastructures, and in telecommunications induce the largest effects, which are of the same order of magnitude for private investment, employment, and output. Investments in road transportation infrastructure have positive but much smaller effects, while the effects of investments in public utilities are negligible.

For example, in terms of the long-term output marginal products, the effects of other transportation, social infrastructures, and telecommunications are €19.95, €18.82, and €12.35, respectively, while for road transportation, it is €5.52.

We consider now the effects of the five main types of infrastructure assets at the more disaggregated level on four different economic activities: primary sector, manufacturing, private services, and public services. These results are reported in Table 4 to Table 8 in the rows with the partials, and again we include only the statistically significant effects. There are stark differences in terms of the industry-specific effects at this level. The effects of the different types of infrastructure investments on the primary sector are either negative or very small, while the effects on manufacturing are generally positive but small. The effects on private services are the largest, followed at a distance by the effects on public services. For example, the effects of other transportation infrastructure investments on the output of private services and public services are €17.27 and €3.68, respectively, the effects of social infrastructures are €13.87 and €4.58, respectively, and the effects of telecommunications are €10.61 and €1.04, respectively. For a sense of perspective, there are no statistically significant positive effects on the primary sector's output, while the largest effect on manufacturing comes from social infrastructure with €1.49.

4.2. The effects at the industry level: A closer look

Next, we consider the effects of the five main types of infrastructure assets across the twenty-two sectors covering the whole spectrum of domestic economic activity.

The effects of investments in **road infrastructure** are reported in **Table 4**. The effects are relatively small and are concentrated mostly on private services, and to a lesser extent on public services, with the effect on manufacturing being much smaller. In the case of the primary sector, it is negative. Looking at the more detailed results, we identify twenty-seven positive effects, six negative effects, and thirty-three that are not statistically significant. We see that for the primary sector and manufacturing sector, the effects are all very small. In terms of private and public services, the picture is richer. For private investment, the largest marginal products accrue to real estate (S18), to professional services (S19), and to public administration (S20). For employment, the benefits accrue mostly to trade (S13) and professional services (S19). In turn, the main benefits in terms of output accrue to real estate (S18) with €2.47. There are much smaller effects on construction (S12), trade (S13), public administration (S20), and education (S21). Overall, all positive effects are very small compared with the effects of other infrastructures.

Table 4. Effects of road transportation investment

	Elasticity			Marginal Product		
	Private Investment	Employment	Output	Private Investment	Employment	Output
Agriculture and Mining				**-0.09**	**0.0**	**-0.18**
Agriculture (S1)	0.1641*	0.0024*	-0.1180	*	*	-0.18
Mining (S2)	-1.4527	0.0545*	-0.0566*	-0.09	*	*
Manufacturing				**0.52**	**1.3**	**0.23**
Food (S3)	0.0882*	-0.0359	0.1138	*	-1.7	0.13
Textiles (S4)	0.3323*	-0.0031*	0.0629*	*	*	*
Paper (S5)	0.1283*	0.0396	-0.0505*	*	1.4	-*
Chemical and pharmaceutical (S6)	1.1317	0.0092*	-0.1251	0.11	*	-0.06
Non-metallic minerals (S7)	0.4417	0.0435	0.1530	0.10	1.6	0.16
Basic metals (S8)	0.3712	0.0162*	-0.0557*	0.05	*	*
Machinery and equipment (S9)	0.6143	0.0031*	0.0965*	0.26	*	*
Private Services				**2.53**	**53.4**	**4.16**
Electricity and gas (S10)	0.2866*	-0.1848	-0.0824*	*	-0.9	*
Water (S11)	0.8385*	-0.1461	-0.0949*	*	-2.2	*
Construction (S12)	0.2550*	0.0125*	0.1429	*	*	0.58
Wholesale and retail trade (S13)	0.4155	0.0628	0.0965	0.37	19.7	0.72
Transportation and storage (S14)	0.4518*	0.0031*	0.0017*	*	*	*
Hospitality (S15)	0.5122	0.0796	0.1558	0.16	8.5	0.39
Telecommunications (S16)	0.3827	0.0007*	-0.0027*	0.17	*	*
Finance (S17)	0.5326	-0.0328*	0.0613*	0.28	*	*
Real estate (S18)	0.2431	0.0055*	0.5827	0.94	*	2.47
Professional services (S19)	0.4446	0.1233	-0.0163*	0.61	28.3	*
Public Services				**0.74**	**8.1**	**1.31**
Public administration (S20)	0.4184	0.0611	0.1094	0.62	8.1	0.51
Education (S21)	0.4842	0.0128*	0.1407	0.12	*	0.51
Health (S22)	0.3256*	0.0082*	0.0936	*	*	0.29
TOTAL				**3.70**	**62.7**	**5.52**

(*) The estimates marked with asterisk are not significantly different from zero, as implied by the standard deviation bands around the accumulated impulse response functions

In terms of infrastructure investments in **other transportation**, the results are reported in **Table 5**. The effects are substantial and overwhelmingly concentrated on private services, and to a lesser extent on public services, while the effects on the primary sector and manufacturing sector are again very small. We identify twenty-nine positive effects, nine negative effects, and twenty-eight that are not statistically significant. For private investment, the largest benefits accrue to construction (S12), trade (S13), transportation and storage (S14), and public administration (S20). For employment, the largest effects are in construction (S12), trade (S13), and professional services (S19), and to a lesser extent in hospitality (S15) and public administration (S20). In terms of the effects on output, the sectors that benefit the most are real estate (S18) with €10.45, followed by construction (S12), trade (S13), public administration (S20), and education (S21), with €2.44, €2.54, €1.70, and €1.79, respectively.

Table 5. Effects of other transportation infrastructure investments

	Elasticity			Marginal Product		
	Private Investment	**Employment**	**Output**	**Private Investment**	**Employment**	**Output**
Agriculture and Mining				**0.56**	**38.9**	*
Agriculture (S1)	0.4602	0.0507	-0.0159*	0.56	32.3	*
Mining (S2)	-1.7191	0.2900	0.0008*	-0.35	6.6	*
Manufacturing				**2.06**	**-22.0**	**-1.00**
Food (S3)	0.5144	-0.0291	0.0718	0.38	-4.5	0.27
Textiles (S4)	0.4315	0.0143*	0.0315*	0.15	*	*
Paper (S5)	0.6064	0.0173*	-0.0536*	0.42	*	*
Chemical and pharmaceutical (S6)	0.8075	0.0009*	-0.0690	0.27	*	-0.10
Non-metallic minerals (S7)	0.0981*	-0.0101*	0.0151*	*	*	*
Basic metals (S8)	0.1424*	-0.0210*	-0.0136*	*	*	*
Machinery and equipment (S9)	0.6038	-0.0679	-0.1832	0.84	-17.5	-1.17
Private Services				**10.45**	**239.2**	**17.27**
Electricity and gas (S10)	0.6703*	-0.0950	0.1714	*	-1.5	0.67
Water (S11)	-0.3523*	-0.0378*	0.1440	*	*	0.22
Construction (S12)	0.6136	0.0975	0.1814	1.19	72.8	2.44
Wholesale and retail trade (S13)	0.4940	0.0507	0.1026	1.46	52.3	2.54
Transportation and storage (S14)	1.1246	0.0175*	-0.0560*	4.15	*	*
Hospitality (S15)	0.9224	0.0834	0.1330	0.96	29.3	1.10
Telecommunications (S16)	0.3642	-0.0215*	-0.0376	0.54	*	-0.15
Finance (S17)	-0.4479	-0.1193	-0.0009*	-0.77	-16.4	*
Real estate (S18)	0.1878*	0.1007*	0.7476	*	*	10.45
Professional services (S19)	0.6419	0.1358	0.0229*	2.92	102.7	*
Public Services				*	**15.4**	**3.68**
Public administration (S20)	0.1967*	0.0352	0.1116	*	15.4	1.70
Education (S21)	0.2413*	0.0150*	0.1492	*	*	1.79
Health (S22)	0.0878*	-0.0295*	0.0192	*	*	0.19
TOTAL				**13.07**	**271.5**	**19.95**

(*) The estimates marked with asterisk are not significantly different from zero, as implied by the standard deviation bands around the accumulated impulse response functions

The effects of **social infrastructure** investments are reported in **Table 6**. Across the four main sectors of economic activity, the benefits are once again overwhelmingly concentrated on private services, and to a lesser extent on public services, being mostly negative for the primary sector and small but generally positive for manufacturing. At a more disaggregated level, we identify thirty-five positive effects, eleven negative effects, and twenty that are not statistically significant. The positive effects on private investment are particularly significant for real estate (S18) and professional services (S19), and very important for trade (S13), finance (S17), and public administration (S20). In terms of employment, we start by noticing sizable negative effects on employment in agriculture (S1), textiles (S4), and hospitality (S15). On the other hand, we see very large effects on employment in construction (S12), trade (S13), and professional services (S19). As to output, there are sizable positive effects on the output of machinery and equipment (S9) and sizable negative effects on the output of electricity and gas (S10) and water (S11). The largest output effects are

Table 6. Effects of social infrastructure investments

	Elasticity			Marginal Product		
	Private Investment	**Employment**	**Output**	**Private Investment**	**Employment**	**Output**
Agriculture and Mining				*	**-60.1**	**-1.12**
Agriculture (S1)	0.1627*	-0.1364	-0.2930	*	-60.1	-1.03
Mining (S2)	-1.8931*	0.0602*	-0.1525	*	*	-0.09
Manufacturing				**2.17**	**5.0**	**1.49**
Food (S3)	0.1629*	0.0143*	0.0562*	*	*	*
Textiles (S4)	0.1150*	-0.0545	-0.1206	*	-13.5	-0.39
Paper (S5)	0.7114	0.0001*	0.1377	0.34	*	0.29
Chemical and pharmaceutical (S6)	1.2704	0.0432	-0.2060	0.29	0.9	-0.21
Non-metallic minerals (S7)	0.8187	0.0913	0.2366	0.43	7.6	0.56
Basic metals (S8)	1.2334	0.1049	0.0347*	0.41	10.0	*
Machinery and equipment (S9)	0.7296	0.0543*	0.2804	0.70	*	1.24
Private Services				**10.15**	**199.7**	**13.87**
Electricity and gas (S10)	1.1682*	-0.0738	-0.4602	*	-0.8	-1.24
Water (S11)	0.6854*	-0.1370	-0.4291	*	-4.6	-0.45
Construction (S12)	0.7300	0.1629	0.3659	0.98	84.2	3.41
Wholesale and retail trade (S13)	0.8651	0.0611	0.0707	1.77	43.7	1.21
Transportation and storage (S14)	0.1068*	0.0742	0.2468	*	11.6	1.37
Hospitality (S15)	-0.0124*	-0.0727	-0.0362*	*	-17.7	*
Telecommunications (S16)	0.0164*	-0.0287*	-0.0297*	*	*	*
Finance (S17)	1.0855	0.0204*	0.2547	1.30	*	2.06
Real estate (S18)	0.3488	0.1755	0.5494	3.08	5.7	5.31
Professional services (S19)	0.9586	0.1482	0.1985	3.02	77.6	2.20
Public Services				**3.21**	**28.5**	**4.58**
Public administration (S20)	0.4642	0.0086*	0.1505	1.57	*	1.59
Education (S21)	1.1187	0.0575	0.2369	0.65	17.1	1.96
Health (S22)	0.7540	0.0359	0.1481	0.99	11.4	1.03
TOTAL				**15.53**	**173.1**	**18.82**

(*) The estimates marked with asterisk are not significantly different from zero, as implied by the standard deviation bands around the accumulated impulse response functions

on construction (S12) with €3.41 and real estate (S18) with €5.31, with very sizable effects on trade (S13), transportation (S14), finance (S17), and professional services (S19), as well as public administration (S20), education (S21), and health (S22).

As to investments in **public utilities**, results are reported in **Table 7**. The results are, with very few exceptions, very small. Indeed, forty of the sixty-six effects estimated are not statistically different from zero.

Table 7. Effects of public utility infrastructure investments

	Elasticity			Marginal Product		
	Private Investment	**Employment**	**Output**	**Private Investment**	**Employment**	**Output**
Agriculture and Mining				**-0.07**	**-3.5**	**-0.12**
Agriculture (S1)	-0.1680	-0.0205	-0.0891	-0.07	-4.2	-0.15
Mining (S2)	0.0955*	0.0953	0.1095	*	0.7	0.03
Manufacturing				**-0.13**	**3.4**	**-0.04**
Food (S3)	-0.1905	0.0107*	-0.0053*	-0.05	*	*
Textiles (S4)	-0.0166*	0.0122	0.0002*	*	1.4	*
Paper (S5)	-0.2232	-0.0051*	-0.0028*	-0.05	*	*
Chemical and pharmaceutical (S6)	-0.0319*	0.0177	-0.0579	*	0.2	-0.03
Non-metallic minerals (S7)	-0.1272	-0.0066*	-0.0113*	-0.03	*	*
Basic metals (S8)	0.2288*	0.0413	0.1307	*	1.8	0.13
Machinery and equipment (S9)	-0.0607*	-0.0108*	-0.0663	*	*	-0.14
Private Services				**1.00**	**-28.6**	**-1.20**
Electricity and gas (S10)	1.3999	0.0156*	-0.0695	0.82	*	-0.09
Water (S11)	1.0323	0.0108*	-0.0381*	0.36	*	*
Construction (S12)	-0.0887*	0.0424*	0.0227*	*	*	*
Wholesale and retail trade (S13)	-0.0715*	0.0046*	0.0156	*	*	0.13
Transportation and storage (S14)	-0.2044*	0.0040*	-0.0202*	*	*	*
Hospitality (S15)	-0.2324	-0.0056*	-0.0023*	-0.08	*	*
Telecommunications (S16)	-0.2096	0.0080*	-0.0027*	-0.10	*	*
Finance (S17)	-0.2227*	-0.0250	-0.0420*	*	-1.1	*
Real estate (S18)	-0.0539*	-0.0829	-0.2726	*	-1.3	-1.24
Professional services (S19)	-0.0433*	-0.1063	0.0103*	*	-26.2	*
Public Services				*	**2.8**	**0.16**
Public administration (S20)	-0.0308*	0.0198	0.0312	*	2.8	0.16
Education (S21)	-0.0285*	0.0036*	-0.0298*	*	*	*
Health (S22)	-0.0011*	-0.0046*	0.0088*	*	*	*
TOTAL				**0.80**	**-25.9**	**-1.20**

(*) The estimates marked with asterisk are not significantly different from zero, as implied by the standard deviation bands around the accumulated impulse response functions

Finally, the effects of investments in **telecommunications** are reported in **Table 8**. Once more, these investments have yet again the greatest impact on private services, with moderate positive effects on the output in public services, employment in all the other sectors, and private investment in manufacturing. Overall, we identify thirty-four positive effects, five negative effects, and seventeen that are not statistically significant. The largest effects on private investment are in transportation (S14), real estate (S18), and professional services (S19), and to a lesser extent in trade (S13), while the largest effects on employment occur in construction (S12), trade (S13), and professional services (S19), and to a lesser extent in hospitality (S15). In terms of output, the largest effects occur in real estate (S18) with €4.47, followed by construction (S12), trade (S13), finance (S17), professional services (S19), and public administration (S20), with effects of €1.79, €1.16, €1.59, €1.19, and €1.04, respectively.

Table 8. Effects of telecommunications infrastructure investment

	Elasticity			Marginal Product		
	Private Investment	**Employment**	**Output**	**Private Investment**	**Employment**	**Output**
Agriculture and Mining				**0.36**	**3.7**	*
Agriculture (S1)	**0.4452**	0.0134*	0.0126*	0.36	*	*
Mining (S2)	-0.3155*	**0.2457**	0.1336*	*	3.7	*
Manufacturing				**2.21**	**23.7**	**0.70**
Food (S3)	**0.7388**	0.0073*	0.0194*	0.37	*	*
Textiles (S4)	**0.7068**	**0.0276**	-0.0146*	0.16	6.6	*
Paper (S5)	**0.7540**	**0.0405**	**0.0955**	0.35	3.2	0.20
Chemical and pharmaceutical (S6)	**0.6313**	**0.0355**	-0.0117*	0.14	0.7	*
Non-metallic minerals (S7)	**0.5976**	**0.0384**	**0.0746**	0.30	3.1	0.17
Basic metals (S8)	**0.6244**	**0.0584**	**0.1609**	0.20	5.3	0.33
Machinery and equipment (S9)	**0.7399**	**0.0280**	0.0276*	0.69	4.8	*
Private Services				**8.91**	**188.6**	**10.61**
Electricity and gas (S10)	**-0.6879**	**-0.0317**	0.0283*	-0.83	-0.3	*
Water (S11)	**-1.3333**	**-0.0643**	0.0294*	-0.96	-2.1	*
Construction (S12)	**0.7664**	**0.1114**	**0.1994**	0.99	55.6	1.79
Wholesale and retail trade (S13)	**0.5943**	**0.0515**	**0.0701**	1.17	35.5	1.16
Transportation and storage (S14)	**0.8416**	**0.0463**	0.0327*	2.07	7.0	*
Hospitality (S15)	**1.1400**	**0.0699**	**0.0946**	0.79	16.4	0.52
Telecommunications (S16)	**0.6483**	0.0003*	**-0.0397**	0.64	*	-0.11
Finance (S17)	**0.3142**	**-0.0282**	**0.2044**	0.36	-2.6	1.59
Real estate (S18)	**0.2806**	**0.0939**	**0.4793**	2.39	2.9	4.47
Professional services (S19)	**0.7542**	**0.1509**	**0.1112**	2.29	76.2	1.19
Public Services				**0.58**	**5.0**	**1.04**
Public administration (S20)	0.1216*	0.0253*	**0.1024**	*	*	1.04
Education (S21)	**0.3463**	**0.0176**	0.0671*	0.19	5.0	*
Health (S22)	**0.3045**	0.0264*	0.0355*	0.39	*	*
TOTAL				**12.06**	**221.0**	**12.35**

(*) The estimates marked with asterisk are not significantly different from zero, as implied by the standard deviation bands around the accumulated impulse response functions

4.3. The effects at the industry level: A different look

A clear picture emerges from these more disaggregated results. The fact is that the benefits of the different types of infrastructure investments accrue mostly to private services, and to a lesser extent to public services, are now sharpened, as even within these industries some seem to benefit the most, while others seem to be mainly unaffected. Let's consider some informative details.

We have identified 110 infrastructure-industry-specific effects on each of private investment, employment, and output. For **private investment**, of the fifty-seven positive effects we have identified, eighteen are around or above €1. Of these, sixteen are in private services: three in construction (S12), trade (S13), real estate (S18), and professional services (S19); two in transportation (S14); and one for hospitality (S15) and finance (S17). The remaining two are in public services. For **employment**, there are forty-five effects that are significantly positive, of which sixteen have more than 15 full-time jobs per one million euros of investment. Of these,

thirteen accrue to private services: four to trade (S13) and professional services (S19), three to construction (S12), and two to hospitality (S15). The remaining three go to public administration (S20), education (S21), and agriculture (S1). Finally, for **output**, there are forty-six effects that are significantly positive, of which twenty-three are greater that €1. Of these, sixteen are in private services: four for real estate (S18), three for construction (S12) and for trade (S13), two for finance (S17) and professional services (S19), with the remaining for transportation (S14) and hospitality (S15). Meanwhile, six are for public services: three for public administration (S20), two for education (S21), and one for health (S22). The remaining effect goes to machinery and equipment (S9).

4.4. On the effects on the composition of economic activity

We now probe more formally into the issue of which industries benefit the most from infrastructure investments. We want to identify the effects of infrastructure investment on the industry mix in Portugal, in particular how it affects the traded/non-traded divide. Our focus is therefore on the industry-specific effects of infrastructure investments, relative to the size of each industry.

To analyze the effects of infrastructure investments on the industry mix, we need to move beyond the magnitude of the effects of infrastructure investments in absolute terms, and turn to the measurement of these effects in relative terms. This means, first, for each sector, the size of its effects relative to the total effects for all sectors and, second, these shares relative to the size of the sector. The point is that the small effects for certain industries may be just a reflection of the fact that these industries are small. Furthermore, even small effects are significant if the share of the total effects they represent exceeds the share of the industry in the total economy. In this case, the marginal effects induced by the infrastructure investments exceed the average size of the sector and, as such, infrastructure investments tend to make such industry relatively more important in the industry mix.

We can conceptualize the results for all industries in four categories, depending on the relative magnitude of the share of the sector of the total effects and the sector share in the total economy. For industries with negative effects or effects that are not statistically different from zero, infrastructure investments have decisively changed the industry mix away from them. For the sectors in which the share of the benefits is positive, but less than one, despite their positive effects, the effects of such infrastructure investments were not enough to bias the industry mix in their favor. Finally, for industries with positive effects, in which the share of positive effects exceeds the share of the industry in the economy, infrastructure investments have biased the industry mix in their favor. The results of infrastructure investments in the industry mix are reported in **Tables 9–13**.

Table 9. Effects of road infrastructure investments on the industry mix

	Private Investment				Employment				Output			
	Marginal Product	**Share of Benefits**	**Share of GFCF**	**Ratio**	**Marginal Product**	**Share of Benefits**	**Share of Empl.**	**Ratio**	**Marginal Product**	**Share of Benefits**	**Share of Output**	**Ratio**
Agriculture and Mining												
Agriculture (S1)	*	*	3.80	*	*	*	14.50	*	-	-	6.70	-
Mining (S2)	-	-	1.00	-	*	*	1.00	*	*	*	1.90	*
Manufacturing												
Food (S3)	*	*	1.40	*	-	-	2.70	-	0.13	2.26	2.10	**1.07**
Textiles (S4)	*	*	1.30	*	*	*	7.40	*	*	*	3.70	*
Paper (S5)	*	*	1.40	*	1.40	2.07	2.30	**0.90**	*	*	2.20	*
Chemical and pharm. (S6)	0.11	2.90	2.00	**1.45**	*	*	0.80	*	-	-	1.70	-
Non-metallic minerals (S7)	0.10	2.64	2.00	**1.32**	1.60	2.37	2.00	**1.18**	0.16	2.78	2.70	**1.03**
Basic metals (S8)	0.05	1.32	1.10	**1.20**	*	*	2.30	*	*	*	2.50	*
Machinery and equipment (S9)	0.26	6.86	4.00	**1.72**	*	*	4.30	*	*	*	3.30	*
Private Services												
Electricity and gas (S10)	*	*	4.90	*	-	-	0.40	-	*	*	2.10	*
Water (S11)	*	*	3.40	*	-	-	0.90	-	*	*	0.60	*
Construction (S12)	*	*	5.30	*	*	*	10.70	*	0.58	10.07	7.10	**1.42**
Wholesale & retail trade (S13)	0.37	9.76	5.60	**1.74**	19.70	29.14	13.90	**2.10**	0.72	12.50	15.40	**0.81**
Transportation & storage (S14)	*	*	5.80	*	*	*	3.50	*	*	*	4.60	*
Hospitality (S15)	0.16	4.22	1.90	**2.22**	8.50	12.57	4.40	**2.86**	0.39	6.77	3.70	**1.83**
Telecommunications (S16)	0.17	4.49	2.70	**1.66**	*	*	0.40	*	*	*	1.90	*
Finance (S17)	0.28	7.39	4.80	**1.54**	*	*	2.30	*	*	*	6.30	*
Real estate (S18)	0.94	24.80	26.60	**0.93**	*	*	0.50	*	2.47	42.88	7.50	**5.72**
Professional services (S19)	0.61	16.09	6.70	**2.40**	28.30	41.86	8.10	**5.17**	*	*	7.20	*
Public Services												
Public administration (S20)	0.62	16.36	10.80	**1.51**	8.10	11.98	8.00	**1.50**	0.51	8.85	8.50	**1.04**
Education (S21)	0.12	3.17	1.70	**1.86**	*	*	5.70	*	0.51	8.85	5.30	**1.67**
Health (S22)	*	*	1.90	*	*	*	3.80	*	0.29	5.03	3.20	**1.57**
		100.00	100.00			100.00	100.00			100.00	100.00	

(*) The effects marked with asterisk are not significantly different from zero, as implied by the standard deviation bands around the accumulated impulse response functions.

The effects market with a minus sign are negative and significantly different from zero.

Table 10. Effects of other transportation infrastructure investments on the industry mix

	Private Investment				Employment				Output			
	Marginal Product	**Share of Benefits**	**Share of GFCF**	**Ratio**	**Marginal Product**	**Share of Benefits**	**Share of Emp.**	**Ratio**	**Marginal Product**	**Share of Benefits**	**Share of Output**	**Ratio**
Agriculture and Mining												
Agriculture (S1)	0.56	4.35	3.80	**1.14**	32.30	10.16	14.50	**0.70**	*	*	6.70	*
Mining (S2)	-	-	1.00	**-**	6.60	2.08	1.00	**2.08**	*	*	1.90	*
Manufacturing												
Food (S3)	0.38	2.90	1.40	**2.07**	-	-	2.70	**-**	0.27	1.41	2.10	**0.67**
Textiles (S4)	0.15	0.72	1.30	**0.56**	*	*	7.40	*	*	*	3.70	*
Paper (S5)	0.42	2.90	1.40	**2.07**	*	*	2.30	*	*	-	2.20	**-**
Chemical and pharm. (S6)	0.27	2.17	2.00	**1.09**	*	*	0.80	*	-	-	1.70	**-**
Non-metallic minerals (S7)	*	*	2.00	*	*	*	2.00	*	*	*	2.70	*
Basic metals (S8)	*	*	1.10	*	*	*	2.30	*	*	*	2.50	*
Machinery and equipment (S9)	0.84	5.80	4.00	**1.45**	-	-	4.30	**-**	-	-	3.30	**-**
Private Services												
Electricity and gas (S10)	*	*	4.90	*	-	-	0.40	**-**	0.67	3.29	2.10	**1.56**
Water (S11)	*	*	3.40	*	*	*	0.90	*	0.22	0.94	0.60	**1.56**
Construction (S12)	1.19	8.70	5.30	**1.64**	72.80	22.91	10.70	**2.14**	2.44	11.27	7.10	**1.59**
Wholesale & retail trade (S13)	1.46	10.87	5.60	**1.94**	52.30	16.46	13.90	**1.18**	2.54	11.74	15.40	**0.76**
Transportation & storage (S14)	4.10	29.71	5.80	**5.12**	*	*	3.50	*	*	*	4.60	*
Hospitality (S15)	0.96	7.25	1.90	**3.81**	29.30	9.22	4.40	**2.10**	1.10	5.16	3.70	**1.40**
Telecommunications (S16)	0.54	3.62	2.70	**1.34**	*	*	0.40	*	-	-	1.90	**-**
Finance (S17)	-	-	4.80	**-**	-	-	2.30	**-**	*	*	6.30	*
Real estate (S18)	*	*	26.60	*	*	*	0.50	*	10.45	48.83	7.50	**6.51**
Professional services (S19)	2.92	21.01	6.70	**3.14**	102.70	32.32	8.10	**3.99**	*	*	7.20	*
Public Services												
Public administration (S20)	*	*	10.80	*	15.40	4.85	8.00	**0.61**	1.70	7.98	8.50	**0.94**
Education (S21)	*	*	1.70	*	*	*	5.70	*	1.79	8.45	5.30	**1.59**
Health (S22)	*	*	1.90	*	*	*	3.80	*	0.19	0.94	3.20	**0.29**
		100.00	100.00			100.00	100.00			100.00	100.00	

(*) The effects marked with asterisk are not significantly different from zero, as implied by the standard deviation bands around the accumulated impulse response functions.

The effects market with a minus sign are negative and significantly different from zero.

Table 11. Effects of social infrastructure investments on the industry mix

	Private Investment				Employment				Output			
	Marginal Product	**Share of Benefits**	**Share of GFCF**	**Ratio**	**Marginal Product**	**Share of Benefits**	**Share of Emp.**	**Ratio**	**Marginal Product**	**Share of Benefits**	**Share of Output**	**Ratio**
Agriculture and Mining												
Agriculture (S1)	*	*	3.80	*	-	-	14.50	-	-	-	6.70	-
Mining (S2)	*	*	1.00	*	*	*	1.00	*	-	-	1.90	-
Manufacturing												
Food (S3)	*	*	1.40	*	*	*	2.70	*	*	*	2.10	*
Textiles (S4)	*	*	1.30	*	-	-	7.40	-	-	-	3.70	-
Paper (S5)	0.34	1.94	1.40	**1.38**	*	*	2.30	*	0.29	1.35	2.20	**0.61**
Chemical and pharm. (S6)	0.29	1.94	2.00	**0.97**	0.90	0.33	0.80	**0.42**	-	-	1.70	-
Non-metallic minerals (S7)	0.43	2.58	2.00	**1.29**	7.60	2.82	2.00	**1.41**	0.56	2.69	2.70	**1.00**
Basic metals (S8)	0.41	2.58	1.10	**2.35**	10.00	3.71	2.30	**1.61**	*	*	2.50	*
Machinery and equipment (S9)	0.70	4.52	4.00	**1.13**	*	*	4.30	*	1.24	5.38	3.30	**1.63**
Private Services												
Electricity and gas (S10)	*	*	4.90	*	-	-	0.40	-	-	-	2.10	-
Water (S11)	*	*	3.40	*	-	-	0.90	-	-	-	0.60	-
Construction (S12)	0.98	6.45	5.30	**1.22**	84.20	31.21	10.70	**2.92**	3.41	15.25	7.10	**2.15**
Wholesale & retail trade (S13)	1.77	11.61	5.60	**2.07**	43.70	16.20	13.90	**1.17**	1.21	5.38	15.40	**0.35**
Transportation & storage (S14)	*	*	5.80	*	11.60	4.30	3.50	**1.23**	1.37	6.28	4.60	**1.36**
Hospitality (S15)	*	*	1.90	*	-	-	4.40	-	*	*	3.70	*
Telecommunications (S16)	*	*	2.70	*	*	*	0.40	*	*	*	1.90	*
Finance (S17)	1.30	8.39	4.80	**1.75**	*	*	2.30	*	2.06	9.42	6.30	**1.49**
Real estate (S18)	3.08	20.00	26.60	**0.75**	5.70	2.11	0.50	**4.23**	5.31	23.77	7.50	**3.17**
Professional services (S19)	3.02	19.35	6.70	**2.89**	77.60	28.76	8.10	**3.55**	2.20	9.87	7.20	**1.37**
Public Services												
Public administration (S20)	1.57	10.32	10.80	**0.96**	*	*	8.00	*	1.59	7.17	8.50	**0.84**
Education (S21)	0.65	3.87	1.70	**2.28**	17.10	6.34	5.70	**1.11**	1.96	8.97	5.30	**1.69**
Health (S22)	0.99	6.45	1.90	**3.40**	11.40	4.23	3.80	**1.11**	1.03	4.48	3.20	**1.40**
		100.00	100.00			100.00	100.00			100.00	100.00	

(*) The effects marked with asterisk are not significantly different from zero, as implied by the standard deviation bands around the accumulated impulse response functions.

The effects market with a minus sign are negative and significantly different from zero

Table 12. Effects of public utilities infrastructure investments on the industry mix

	Private Investment				Employment				Output			
	Marginal Product	**Share of Benefits**	**Share of GFCF**	**Ratio**	**Marginal Product**	**Share of Benefits**	**Share of Emp.**	**Ratio**	**Marginal Product**	**Share of Benefits**	**Share of Output**	**Ratio**
Agriculture and Mining												
Agriculture (S1)	-	-	3.80	-	-	-	14.50	-	-	-	6.70	-
Mining (S2)	*	*	1.00	*	0.7	10.14	1.00	**10.14**	0.03	6.67	1.90	**3.51**
Manufacturing												
Food (S3)	-	-	1.40	-	*	*	2.70	*	*	*	2.10	*
Textiles (S4)	*	*	1.30	*	1.4	20.29	7.40	**2.74**	*	*	3.70	*
Paper (S5)	-	-	1.40	-	*	*	2.30	*	*	*	2.20	*
Chemical and pharm. (S6)	*	*	2.00	*	0.2	2.90	0.80	**3.62**	-	-	1.70	-
Non-metallic minerals (S7)	-	-	2.00	-	*	*	2.00	*	*	*	2.70	*
Basic metals (S8)	*	*	1.10	*	1.8	26.09	2.30	**11.34**	0.13	28.89	2.50	**11.56**
Machinery and equipment (S9)	*	*	4.00	*	*	*	4.30	*	-	-	3.30	-
Private Services												
Electricity and gas (S10)	0.82	69.49	4.90	**14.18**	*	*	0.40	*	-	-	2.10	-
Water (S11)	0.36	30.51	3.40	**8.97**	*	*	0.90	*	*	*	0.60	*
Construction (S12)	*	*	5.30	*	*	*	10.70	*	*	*	7.10	*
Wholesale & retail trade (S13)	*	*	5.60	*	*	*	13.90	*	0.13	28.89	15.40	**1.88**
Transportation & storage (S14)	*	*	5.80	*	*	*	3.50	*	*	*	4.60	*
Hospitality (S15)	-	-	1.90	-	*	*	4.40	*	*	*	3.70	*
Telecommunications (S16)	-	-	2.70	-	*	*	0.40	*	*	*	1.90	*
Finance (S17)	*	*	4.80	*	-	-	2.30	-	*	*	6.30	*
Real estate (S18)	*	*	26.60	*	-	-	0.50	-	-	-	7.50	-
Professional services (S19)	*	*	6.70	*	-	-	8.10	-	*	*	7.20	*
Public Services												
Public administration (S20)	*	*	10.80	*	2.8	40.58	8.00	**5.07**	0.16	35.56	8.50	**4.18**
Education (S21)	*	*	1.70	*	*	*	5.70	*	*	*	5.30	*
Health (S22)	*	*	1.90	*	*	*	3.80	*	*	*	3.20	*
		100.00	100.00			100.00	99.90			100.00	100.00	

(*) The effects marked with asterisk are not significantly different from zero, as implied by the standard deviation bands around the accumulated impulse response functions.

The effects market with a minus sign are negative and significantly different from zero.

Table 13. Effects of telecommunication infrastructure investments on the industry mix

	Private Investment				Employment				Output			
	Marginal Product	**Share of Benefits**	**Share of GFCF**	**Ratio**	**Marginal Product**	**Share of Benefits**	**Share of Emp.**	**Ratio**	**Marginal Product**	**Share of Benefits**	**Share of Output**	**Ratio**
Agriculture and Mining												
Agriculture (S1)	0.36	2.60	3.80	**0.68**	*	*	14.50	*	*	*	6.70	*
Mining (S2)	*	*	1.00	*	3.7	1.64	1.00	**1.64**	*	*	1.90	*
Manufacturing												
Food (S3)	0.37	2.67	1.40	**1.91**	*	*	2.70	*	*	*	2.10	*
Textiles (S4)	0.16	1.16	1.30	**0.89**	6.6	2.92	7.40	**0.39**	*	*	3.70	*
Paper (S5)	0.35	2.53	1.40	**1.81**	3.2	1.42	2.30	**0.62**	0.2	1.61	2.20	**0.73**
Chemical and pharm. (S6)	0.14	1.01	2.00	**0.51**	0.7	0.31	0.80	**0.39**	*	*	1.70	*
Non-metallic minerals (S7)	0.3	2.17	2.00	**1.08**	3.1	1.37	2.00	**0.69**	0.17	1.36	2.70	**0.51**
Basic metals (S8)	0.2	1.44	1.10	**1.31**	5.3	2.35	2.30	**1.02**	0.33	2.65	2.50	**1.06**
Machinery and equipment (S9)	0.69	4.98	4.00	**1.25**	4.8	2.12	4.30	**0.49**	*	*	3.30	*
Private Services												
Electricity and gas (S10)	-	-	4.90	**-**	-	-	0.40	**-**	*	*	2.10	*
Water (S11)	-	-	3.40	**-**	-	-	0.90	**-**	*	*	0.60	*
Construction (S12)	0.99	7.15	5.30	**1.35**	55.6	24.60	10.70	**2.30**	1.79	14.37	7.10	**2.02**
Wholesale & retail trade (S13)	1.17	8.45	5.60	**1.51**	35.5	15.71	13.90	**1.13**	1.16	9.31	15.40	**0.60**
Transportation & storage (S14)	2.07	14.95	5.80	**2.58**	7	3.10	3.50	**0.88**	*	*	4.60	*
Hospitality (S15)	0.79	5.70	1.90	**3.00**	16.4	7.26	4.40	**1.65**	0.52	4.17	3.70	**1.13**
Telecommunications (S16)	0.64	4.62	2.70	**1.71**	*	-	0.40	**-**	-	-	1.90	**-**
Finance (S17)	0.36	2.60	4.80	**0.54**	-	-	2.30	**-**	1.59	12.76	6.30	**-**
Real estate (S18)	2.39	17.26	26.60	**0.65**	2.9	1.28	0.50	**2.57**	4.47	35.87	7.50	**4.78**
Professional services (S19)	2.29	16.53	6.70	**2.47**	76.2	33.72	8.10	**4.16**	1.19	9.55	7.20	**1.33**
Public Services												
Public administration (S20)	*	*	10.80	*	*	*	8.00	*	1.04	8.35	8.50	**0.98**
Education (S21)	0.19	1.37	1.70	**0.81**	5	2.21	5.70	**0.39**	*	*	5.30	*
Health (S22)	0.39	2.82	1.90	**1.48**	*	-	3.80	**-**	*	*	3.20	*
		100.00	100.00			100.00	100.00			100.00	100.00	

(*) The effects marked with asterisk are not significantly different from zero, as implied by the standard deviation bands around the accumulated impulse response functions.

The effects market with a minus sign are negative and significantly different from zero.

Consider, first, the effects on the industry mix of investments in **road infrastructures**. In terms of private investment, the largest relative gains go to hospitality (S15), professional services (S19), and education (S21), while for employment, the largest relative gains go to trade (S13), hospitality (S15), and professional services (S19). Finally, in terms of the output mix, the largest gains in relative terms accrue to hospitality (S15), real estate (S18), education (S21), and health (S22), and to a lesser extent to construction (S12). In turn, food (S3), non-metallic minerals (S7), trade (S13), and public administration (S20) are largely unaffected in terms of their share of GDP.

For **other transportation infrastructure** investments, in terms of private investment, the largest relative gains go to transportation (S14), hospitality (S15), and professional services (S19), while for employment the largest relative gains go construction (S12), hospitality (S15), and professional services (S19). For output, real estate (S18) is the largest beneficiary in relative terms, followed by electricity and gas (S10), water (S11), construction (S12), hospitality (S15), and education (S21).

We now consider the effects of **social infrastructure** investments. In terms of private investment, the large relative gains accrue to basic metals (S8), trade (S13), and professional services (S19), while for employment we see high relative gains for construction (S12), real estate (S18), and professional services (S19). For output, the largest relative gains accrue to construction (S12) and real estate (S18), followed by machinery and equipment (S9), transportation and storage (S14), finance (S17), and professional services (S19).

The case of investments in **public utilities** is not particularly interesting or informative, as their absolute effects tend to be rather small and therefore, regardless of their relative magnitude, make very little actual difference in terms of the actual industry mix. Finally, for investments in **telecommunication infrastructures**, for private investment the largest relative gains accrue to transportation (S14), hospitality (S15), and professional services (S19), while the largest relative employment and output effects go to construction (S12), real estate (S18), and professional services (S19).

Let's now consider the same issue from an industry perspective. We focus on the industries with relative ratios above one, that is, cases in which infrastructure investment clearly biases the economic mix towards those industries. We ignore the case of public utilities.

As to the **investment mix**, there are forty cases in which the ratio is greater than one. Of these, four are in machinery and equipment (S9), trade (S13), and professional services (S19), and three in paper (S5), basic metals (S8), construction (S12), and hospitality (S15). The remaining cases are evenly split between traded and non-traded good sectors.

As far as the **employment mi**x is concerned, there are twenty-five ratios that are larger than one. Of these, four relate to retail (S13) and professional services (S19), three to construction (S12) and hospitality (S15), and two each to mining (S2), non-metallic minerals (S7), real estate (S18), and public administration (S20). The remaining are basic metals (S8), transportation (S14), and education (S21).

In terms of the effects on the **output mix**, there are twenty-four effects with relative ratios above one. Of these, four relate to both construction (S12) and real estate (S18), three to each of hospitality (S15) and education (S21), and two to professional services (S19) and health (S22). Of these, only hospitality and professional services are emerging traded goods sectors. The remaining cases are

basic metals (S8), machinery and equipment (S9), and transportation (S14), which are traded goods sectors, and electricity (S10) and finance (S17), which are not.

5. Summary and concluding remarks

We employ a VAR approach to estimate industry-specific effects of investments in infrastructures for twenty-two industries covering the whole spectrum of economic activity in Portugal and for five types of infrastructure assets. We address two main research questions. First, we want to identify the industries that benefit the most in absolute terms from the different types of infrastructure investments. Second, we want to identify which industries benefit the most relative to their size and therefore how infrastructure investments have affected the composition of economic activity. In both cases, we are interested in identifying differences across the traded and non-traded goods industries divide.

As to the first question, at the aggregate level, the most important effects come from infrastructure investments in other transportation, social infrastructures, and telecommunications, with less important effects from road infrastructures and insignificant effects from public utilities. We also find that the benefits tend to accrue mostly to private services and to a lesser extent to public services, with typically detrimental effects on the primary sector and more mixed effects on the manufacturing sector. Considering the industry effects in full detail, we find that no traded good industry seems to have benefited in any meaningful way from the different types of infrastructure investments. Of the emerging traded good industries, only hospitality and professional services seem to have greatly benefited. Finally, the biggest winners in absolute terms were the non-traded goods industries of construction, trade, real estate, and public administration.

As to the second question, we find that, overall, the ten industries producing traded goods lost ground in their relative importance due to the impact of infrastructure investments. This is despite some relative gains across the board for non-metallic minerals, basic metals, machinery and equipment, and transportation, as well as some employment gains for mining and private investment gains for paper. To be noted, even in these cases, the absolute magnitude of the effects is small. Among the five emerging traded sectors, only hospitality and professional services seem to have benefited in relative terms. Finally, the largest gains in relative terms across the board can be found among the following non-traded goods industries: construction, trade, real estate, education, and health.

There are several important policy implications we can draw from these results. They stem from the key finding that the positive aggregate effects of the different types of infrastructure investments mask rather diverse effects at the industry level. First, it important to recognize that infrastructure strategies are far from neutral, in that they effectively represent picking winners and losers at the industry level. Moreover, the fact that the lopsided benefits accrue mostly to non-traded industries represents a push in the direction of a development model based on domestic demand that may not be sustainable given its implications for the foreign account position of the country.

Second, and from a prospective standpoint, there is the issue of what can be expected from investments that are currently being considered. The great focus for the next few decades will likely be on non-road transportation and social infrastructures. Indeed, the time has passed for any

further focus on road infrastructure, which has achieved a high level of maturity, while investments in public utilities and telecommunications are now mostly in the hands of the private sector and therefore less directly affected by public policy. As per our results, infrastructure investments in the areas of other transportation and social infrastructures will have important aggregate effects, but these will also bias the industry mix towards non-traded goods. In relative terms, investments in other transportation mostly favor employment in construction, hospitality, real estate, and professional services, and output in construction, real estate, and education. In turn, investments in social infrastructures tend to increase the share of employment in construction, real estate, and professional services, as well as the traded industries such as non-metallic minerals and basic metals, and the share of output in construction, finance, real estate, education, and health, as well as the traded industry of machinery and equipment.

The results presented in this article open the door to several important research avenues. The first avenue would be to probe in more detail into the effects of different individual infrastructure assets. For example, does it make any difference for the industry mix if road infrastructure investments are in the form of municipal roads or highways? Or if other transportation investments are in railroads or ports? Or, still, if social infrastructure investments are in educational or health facilities? The second possible avenue of research would be a more detailed look at these issues from the perspective of different individual industries, so as to shed light on how each industry fits into the development model of the country, on one hand, and how infrastructure and industrial policies interact, on the other. For example, for a traded industry, such as textiles, or an emerging traded industry, such as finance or hospitality, how have infrastructure policies affected their performance? The third avenue could be to investigate the meaning of the patterns of results we identified at the industry level as they relate to the nature of the effects of infrastructure investments and the channels through which they affect economic performance. For example, what is the significance of the fact that the benefits to construction and real estate are pervasive? Finally, it would be interesting to analyze the interaction between infrastructure investments and, for example, foreign direct investment, as clearly not all infrastructure assets affect these investments in the same form, and such investments are regarded as key to growth and real convergence in the country.

To conclude, it is worth mentioning that although this research is an application to the Portuguese case, and is intended to be more directly relevant from the perspective of policy making in Portugal, its interest is far from parochial. In the E.U. context, Greece, Ireland, Portugal, and to a lesser extent Italy and Spain, all benefited after the early 1990s from important community structural transfers, which in no small part targeted large infrastructure projects. The same is true in more recent years for the more recent E.U. entrants from Eastern Europe. All of these countries critically depend on improved international competitiveness to maintain a rising standard of living. Whether infrastructure investments lead to favorable aggregate outcomes that hide a bias towards traded or towards non-traded goods is therefore a critical piece of information when designing development strategies that rely to a meaningful extent on infrastructure development.

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